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A COST COMPARISON OF ALTERNATIVE SYSTEMS FOR SHIPPING CITRUS IN REFRIGERATED HIGHWAY TRAILER VANS

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PREFACE

This publication, reporting research on less costly and more efficient systems of handling and transporting citrus, compares the estimated costs of five systems for shipping citrus from the packinghouse to distribution warehouse.

The research was conducted in Florida, Texas, and Ohio, and is part of a broader program of research to develop systems that will reduce the costs of distributing agricultural products.

Numerous shippers and receivers of citrus supplied the facilities and equipment to make this study possible.

B. Russell Robertson and Harold G. Love, extension specialists in agricultural marketing, Cooperative Extension Service, University of Kentucky, provided the data for unloading and receiving citrus in the distribution warehouse. Albert Biales and Thomas Moffitt, Southern Region, Agricultural Research Service, Orlando, Fla. assisted in gathering data on loading at the packinghouse.

This study was conducted under the general supervision of John C. Bouma, chief, Market Operations Research Laboratory.

Upon request, single free copies of this publication may be obtained from the Market Operations Research Laboratory, Agricultural Marketing Research Institute, ARS-USDA, Beltsville, Md. 20705.

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A COST COMPARISON OF ALTERNATIVE SYSTEMS FOR SHIPPING CITRUS IN REFRIGERATED HIGHWAY TRAILER VANS

By

Joseph P. Anthony, Jr., and Thomas H. Camp [1]

SUMMARY

Costs of six systems for shipping citrus in refrigerated highway trailer vans were developed. The six systems included citrus handled and shipped by the following methods: System 1 (forklift truck nonunitized), System 2 (conveyor or nonunitized), System 3 (slipsheet unitized), System 4 (palletized), System 5 (pallet-pool), and System 6 (pallet bin). All of the systems except System 5 (pallet-pool) are presently operating or have operated in actual shipments. Models were constructed to reflect costs for grapefruit between central Florida (Orlando) and Cincinnati, Ohio; but the labor and equipment inputs are also applicable to oranges and to any pair of shipping points.

System 6 (pallet bin) had the highest total system cost at $926.47 per truckload. This amount was $126.40 more per van than the least expensive operational system--System 3 (slipsheet unitized), which had a total system cost of $800.07. System 4's (palletized) total system cost was $817.10 per truckload, or $17.03 more per truckload than the cost of System 3 (slipsheet unitized). System 2 (conveyor nonunitized) had a total system cost of $809.63, or $9.56 more than the cost of system 3. System 1 (forklift truck nonunitized) had a total system cost of $803.86 per truckload. This amount was $3.79 more per truckload than the cost of system 3 (slipsheet unitized).

The synthesized system, system 5 (pallet-pool), had the lowest total system cost at $798.14. However, because it was not operational, this system was presented to show its potential and the need for future research in this area.

With the small margins that occur within the food industry taken into consideration, the differences (in total system cost) between the two nonunitized systems--forklift truck and conveyor--and two of the operational unitized systems--slipsheet and palletized are important. The pallet bin system had higher total system costs because of the high materials costs.

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Controllable costs can be reduced in the operational systems from 17 to 76 percent by using System 3 (slipsheet unitized) rather than by systems 1, 2, 4, or 6. System 5 (pallet-pool) was hypothetical and as such has been excluded from comparison.

INTRODUCTION

Shipments of fresh citrus are of major importance to the U.S. agricultural industry. Rapidly rising labor and equipment costs have increased interest in, and experimentation with, unitized shipments of fresh citrus from Florida on pallets and slipsheets and in pallet bins.

Most fresh citrus shipments from Florida and Texas move by truck. This publication covers the costs of six shipping systems for transporting citrus from Florida to the Midwest in refrigerated highway trailer vans. This publication was limited to highway applications of unitized and nonunitized handling. The California fresh citrus industry is a heavy user of railroad service.

The unitized systems employ the basic principles of unitization and can offer many benefits--less handling, better protection, faster processing, reduced loss and damage, shorter transportation time, and lower rates. Unitization is more than pallets, boxes, pallet patterns, and materials handling equipment; it also involves volume capability, physical compatibility, carrier acceptance, transportation equipment and its utilization, controls and communications, and warehousing.

To facilitate comparison of the total system costs, only one shipping point, Orlando, Fla., and one receiving point, Cincinnati, Ohio, and one type of citrus, grapefruit, were used. This report attempts to measure the labor, materials, and equipment inputs for unitized (using corrugated fiberboard slipsheets, expendable wooden pallets, and corrugated fiberboard pallet bins) and nonunitized (using two different loading methods) loading, transporting, and unloading). The results indicate the inputs required at the particular facilities where the studies were made. Use of the same systems at different facilities may give slightly different results.

PROCEDURE

For the purposes of this publication, a shipping system is composed of three functions: Loading, transporting, and unloading. All labor, materials, and equipment inputs related to completing these functions are included as parts of the six shipping systems.

Both unitized and nonunitized loading and unloading methods were analyzed to measure labor, materials, equipment requirements, and costs. These costs were measured in man-hours and equipment-hours. The labor man-hour requirements were converted to costs using the prevailing wage rates for these job categories as reported by the Bureau of Labor Statistics (1973). The equipment-hour requirements were converted to costs by using hourly ownership and operating costs shown in table 1.

TABLE 1.--Development of hourly ownership and operating costs for equipment inputs required for nonunitized and unitized loading and unloading of citrus

Operation and Equipment	Cost	Estimated life	Annual depreciation [1]	Insurance & taxes [2]	Interest [3]	Total fixed costs	Power [4]	Maintenance [5]	Total variable cost	Total costs	Estimated use per year	Estimated costs per hour
	Dollars	Years	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Hours	Dollars
Loading:												
Forktruck	9,097.00	8	1,137.13	363.88	272.91	1,773.92	181.94	136.46	318.40	2,092.32	1,200	1.74
Pallets [6]	126.72	[7] 3	42.24	5.07	3.80	51.11	--	[8] 31.68	31.68	82.79	1,200	0.07
Dockplate	300.00	4	75.00	12.00	9.00	96.00	--	--	--	96.00	900	0.11
Conveyor belt	[9] 16,600.00	8	2,075.00	664.00	498.00	3,237.00	120.96	249.00	369.96	3,606.96	1,200	3.01
Roller conveyors	[10] 405.00	5	81.00	16.20	12.15	109.35	--	6.08	6.08	115.43	900	0.13
Push-pull attachment	4,680.00	8	585.00	187.20	140.40	912.60	--	70.20	70.20	982.80	1,200	0.82
Unloading:												
Forktruck	9,097.00	8	1,137.13	363.88	272.91	1,773.92	181.94	136.46	318.20	2,092.32	2,100	1.00
Palletjack	2,400.00	5	480.00	96.00	72.00	648.00	--	36.00	36.00	684.00	2,100	0.33
Battery 12.58 Kw.-hr	1,165.00	6	194.17	46.60	34.95	275.72	--	15.00	15.00	290.72	2,100	0.14
Charger	500.00	10	50.00	20.00	15.00	85.00	[11] 110.96	4.50	115.46	200.46	2,100	0.10
Pallets [6]	126.72	[7] 3	42.24	5.07	3.80	51.11	--	[8] 31.68	31.68	82.79	2,100	0.04
Dockplate	300.00	4	75.00	12.00	9.00	96.00	--	--	--	96.00	1,400	0.07
Push-pull attachment	4,680.00	8	585.00	187.20	140.40	912.60	--	70.20	70.20	982.80	2,100	0.47
Pallets [6]	63.36	3	21.12	2.53	1.90	25.55	--	15.84	15.84	41.39	2,100	0.02

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[1] Straight-line depreciation.

[2] Insurance and taxes at 4 percent of initial costs.

[3] Interest at 3 percent of initial costs or 6 percent of the undepreciated balance.

[4] Power at 2.0 percent of initial costs for gas powered equipment. Electric power based on an average power rate of $0.021 per kilowatt-hour, commercial power schedule. Source: Federal Power Commission.

[5] Maintenance at 1.5 percent of initial costs.

[6] Pallets at $3.52. For handling purposes. Use 36 pallets per truckload for nonunitized handling and 18 pallets per truckload for unitized handling.

[7] Strobel, J. "First complete study shows a pallet can save $500." Modern Materials Handling, August 1968.

[8] For 36 pallets at $0.88 per pallet for repairs--$31.68. Strobel, J. and Wallin, W. "Unit load explosion in the food industry." USDA Forest Service Research paper, NE-121, 1969.

[9] Four sections 94 feet by 12 inches at $4,150 per section = $16,600.

[10] Three sections 9 feet by 12 inches at $135 per section = $405.

[11] Power costs for battery charging of electric-powered vehicles are computed from manufacturer's specifications. The formula used is as follows: Battery capacity (kw.-hr.) x discharge rate per hour (10 percent of battery capacity) x 2 (50 percent charging efficiency) x cost of electricity per kilowatt-hour ($0.021) x hours of use per year (2,100) = power costs (dollars per year). For example: 12.58 x 0.10 x 2 x 0.021 x 2,100 = $110.96.

Studies on nonunitized loading methods were conducted at five citrus packinghouses, three of which used forklift trucks (fig. 1) and two of which used conveyors for transporting citrus to the trailer vans for manual loading. Studies on nonunitized unloading methods were conducted at six receivers' warehouses. A minimum of 20 studies of each loading and unloading method was conducted.

Unitized loading methods were studied at five packinghouses, three of which used slipsheet unitized loading, one of which used palletized loading (fig. 2), and one used pallet bin loading. Unitized unloading was studied at three receivers' facilities. A minumum of 20 studies of each loading and unloading method was conducted.

To measure the loading operation with consistency, it was necessary to determine when the storage after packing ended and the loading of the vehicle began. Seldom was the fruit loaded into the vehicle directly after being packed. For this study, loading began at the moment the commodity was moved from the storage area to the transport vehicle. The loading was complete when the last box or handling unit was securely in place in the transport vehicle.

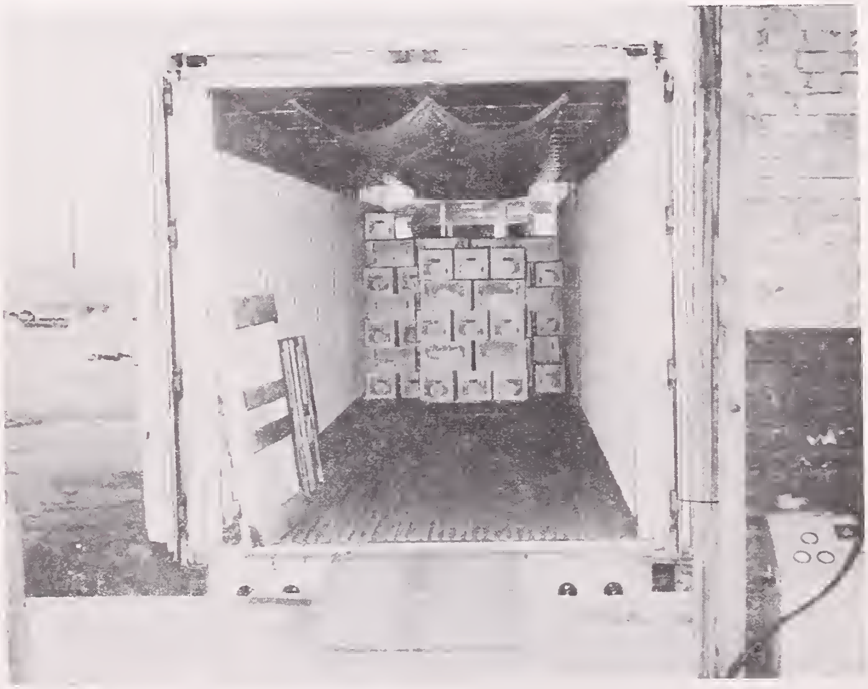

Figure 1.--Citrus boxes being loaded into a highway trailer van by System 1--forktruck nonunitized method.

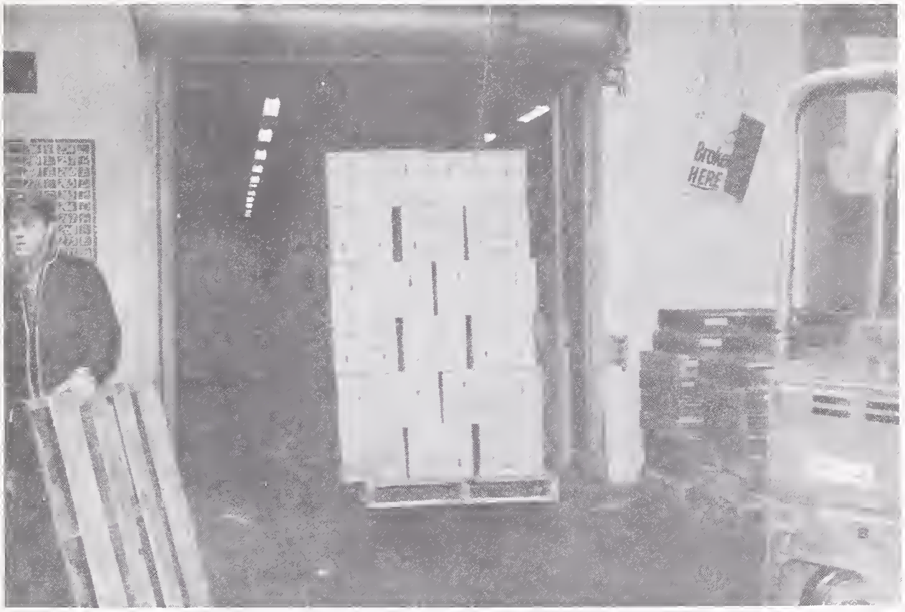

Figure 2.--Boxes of citrus being moved to the refrigerated highway trailer van in System 4--the palletized shipping system.

This did not include opening and closing trailer doors and placing dockplate. All loading studies began and ended at these points.

The transportation of the commodities began when the last box or handling unit was securely in place in the vehicle at origin and ended when the first box or handling unit was unloaded at destination.

As in the loading operation, it was necessary to determine when the unloading of the vehicle began and when the storage after unloading began. Unloading began at the moment the first box or handling unit was removed from the transport vehicle and taken to the storage area. The unloading was complete when the last box or handling unit was in place in the storage area. This did not include opening and closing trailer doors and handling dockplate (fig. 3). All unloading studies began and ended at these points.

Each shipping system began when the first box or handling unit was moved from the shipper's storage area to the transport vehicle and ended when the last box or handling unit was in place in the receiver's storage area.

These shipping systems are only a part of the total distribution or marketing systems which begin in the citrus groves and end on the consumer's table. This research dealt only with the shipping segments of the total distribution systems.

Figure 3.--Handling units on fiberboard slipsheets being unloaded from a highway trailer van.

To facilitate the construction of the shipping system models, one origin, Orlando, Fla.; one destination, Cincinnati, Ohio; and one type of citrus, grapefruit, were used to calculate the transportation costs for all of the shipping systems. For more specific applications, the transportation costs between any pair of points and for other citrus fruits can be substituted in the models.

Corrugated fiberboard slipsheets, expendable wooden pallets, corrugated fiberboard pallet bins, and nylon reinforced tape were the materials used for the unitized shipping systems.

Most Florida citrus is shipped in two sizes of corrugated fiberboard boxes, the 4/5-bushel box with outside dimensions of 17 3/4 by 11 3/4 by 10 3/4 inches and the bagmaster box with outside dimensions of 21 3/4 by 12 1/2 by 11 3/4 inches. The 4/5-bushel box, which is more commonly used than the bagmaster, was used for this study. Since the basic handling inputs are the same for both boxes, the 4/5-bushel box was chosen for convenience. A separate unitized stacking pattern can be used for each type of box. The top layer of each unit was strapped horizontally with 3/4-inch-wide nylon-reinforced tape to increase the stability of the handling unit.

A hypothetical pallet-pool arrangement was constructed for one of the unitized systems. The representative pallet was 48- by 40- by 5-inch, 4-way entry with an average weight of 80 pounds.

In the unitized systems, a total of 864 boxes (18 units of 48 boxes) were loaded into each van. In the nonunitized systems an average of 875 boxes were loaded. To minimize the effect of this variable, all the figures were given a slight adjustment to make them reflect a standard size load of 864 boxes. With transport rates calculated on a per box basis and loading and unloading inputs adjusted, the per box cost for each system has not been disturbed.

The pallet bin loads consisted of 36 pallet bins per truckload. The figures for these loads were not adjusted because of the highly similar total net weights of the two types of loads and the difficulty in obtaining comparability with boxed loads.

A refrigerated highway trailer van 40 feet long was the transport vehicle.

The two nonunitized shipping systems studied differed only in the method of loading. In system 1 a forklift truck transported a palletized unit from the storage area into the trailer. Then two men removing the boxes from the loaded pallets manually stacked them in the van. In system 2 a conveyor moved the boxes from the storage area into the van for handstacking.

One method of unloading was used in both nonunitized shipping systems. In this method one man removed the boxes from the stacking pattern and stacked them on a pallet. He then used a palletjack to move these palletized units out of the van onto the dock. A forklift truck then picked up the loaded pallet and moved it to the storage area.

For nonunitized loads the driver is usually responsible for unloading his truck onto the receiver's dock. The man-hours required for unloading were converted to costs by using the prevailing wage rate as reported by the Bureau of Labor Statistics.

Four unitized shipping systems were studied or synthesized. The first one (system 3) used fiberboard slipsheets. A forklift truck was modified with a special push-pull attachment that grasped the slipsheet which extended beyond the handling unit on one side and pulled the unit onto or pushed the unit off of the tines of the forklift truck. This attachment also included a side-shifting feature that enabled the driver to position the unit without moving the forklift truck.

The second one (system 4) used palletized handling. The boxes were stacked and secured on an expendable pallet directly off the packing line. These palletized units were handled as individual units throughout the system until they were broken up at the receiver's warehouse. A conventional forklift truck was used for all handling operations in this shipping system.

The third one (system 5) was constructed to include a pallet-pool arrangement. The other inputs are identical to System 4 except for the materials cost. Nationwide pallet pooling may be a reality in the near future. This system was synthesized to include this eventuality.

The fourth one (system 6) used fiberboard pallet bins (fig. 4). The citrus fruit was loaded in bulk into the pallet bins which were on wooden pallets. These units were then handled by conventional forklift trucks at loading and unloading.

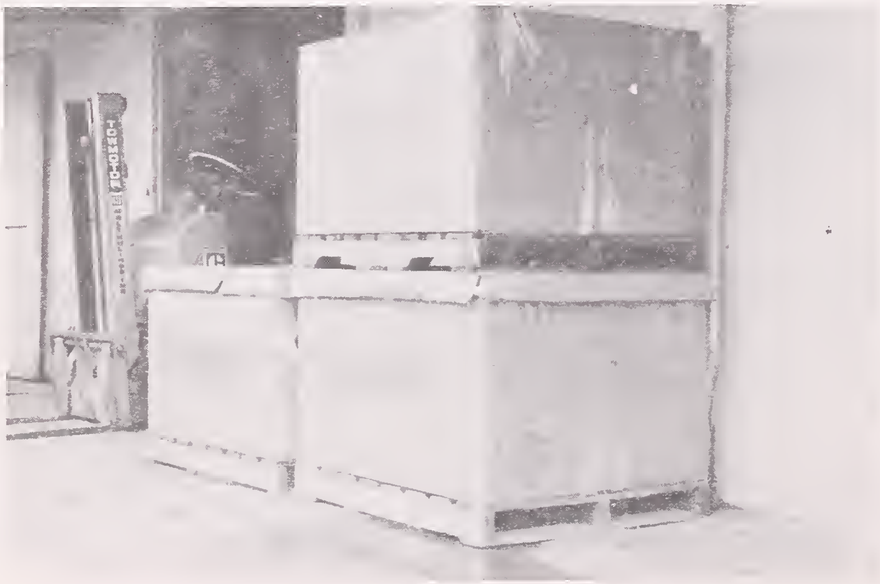

Figure 4.--Fiberboard pallet bins on pallets in the storage area.

The costs for the various inputs for the three operations (loading, transporting, and unloading) in each shipping system are compared by the relative input costs, the operations costs, and total system costs.

RESULTS

System 1--Forklift Truck Nonunitized

Loading--In this method of nonunitized handling, a forklift truck carried a palletized unit from the storage area into a refrigerated highway trailer van. Two men then removed the boxes from the pallet and stacked them in the van. A third man served as a checker-supervisor. The labor requirements and costs to load a van with 864 boxes were as follows:

Labor element	Man-hours 1/	Dollars
Transport loaded pallets from storage into truck 2/	0.659	2.05
Remove boxes from pallet and stack in vehicle 3/	1.317	3.40
Move empty pallets out of vehicle 3/	.192	.49
Wait for next palletload 3/	.330	.85
Supervise loading 2/	.460	1.43
Total	2.958	8.22

1/ Adjusted to an 864-box truckload.

2/ Average wage rate is $3.11 per hour for forklift truck operators and for supervisors, Area Wage Survey, Bureau of Labor Statistics--Laborers-Materials Handling, central Florida. Wage rate does not include cost of fringe benefits.

3/ Average wage rate is $2.58 per hour for loaders, Area Wage Survey, Bureau of Labor Statistics--Laborers-Materials Handling, central Florida. Wage rate does not include cost of fringe benefits.

To get better utilization of the handling equipment, the forklift truck was used to transport boxes to two trucks being loaded at the same time. The dock foreman supervised the loading operations as a part of his job, so that he did not supervise the entire loading of one truck but was present periodically. Thus, 25 percent of his time was allocated to the loading of each truck. Equipment inputs per hour per truckload averaged 0.659 equipment-hour for the forklift truck and 0.920 each equipment-hour for the pallets and dockplate. At an ownership and operating cost of $1.74 per hour for the forklift truck and $0.18 per hour for the pallets and dockplate (table 1), the equipment costs were $1.31. The total labor and equipment handling costs of loading one highway van were $9.53.

Transportation.--At a rate of $0.90 per box to move grapefruit from central Florida to Cincinnati, Ohio, the transportation cost to move an 864-box truckload was $777.60.

Unloading.--In the nonunitized method of unloading, one man removed the boxes from the stacking pattern in the van and stacked them on a pallet. He then used a palletjack to move these palletized units out of the van and onto the dock. A forklift truck then carried the palletized units from the dock to the storage area. The labor requirements and costs of unloading 864 boxes were as follows:

Labor elements	Man-hours 1/	Dollars
Remove boxes from stacking pattern, stack on pallet, and move out of vehicle 2/	1.909	7.31
Delays in unloading 3/	.421	1.61
Move loaded pallets from dock to storage 4/	.665	2.75
Wait for next palletload 4/	.255	1.06
Supervise unloading 4/	.582	2.41
Total	3.832	15.14

1/ Adjusted to an 864-box truckload.

2/ Average wage rate is $3.83 per hour for laborers. Area Wage Survey, Bureau of Labor Statistics--Laborers-Materials Handling, Cincinnati, Ohio. Wage rate does not include cost of fringe benefits.

3/ Delays include personal time plus work stoppage caused by handling equipment.

4/ Average wage rate is $4.14 per hour for forklift truck operators and supervisors, Area Wage Survey, Bureau of Labor Statistics--Laborers-Materials Handling, Cincinnati, Ohio. Wage rate does not include cost of fringe benefits.

The forklift truck was used to move pallets of citrus boxes from three trucks being unloaded at the same time. A dock foreman supervised more than one unloading at any one time. Equipment inputs per hour per truckload averaged 0.924 equipment-hour for the forklift truck, 0.716 equipment-hour for the palletjack, and 2.342 equipment-hours for the pallets and dockplate. At an ownership and operation cost of $1.00 per hour for the forklift truck, $0.57 per hour for the palletjack, and $0.11 per hour for the pallets and dockplate (table 1), the equipment costs were $1.59. Because materials-handling equipment is used more hours per day at the receiver's warehouse, cost per hour is lower than at the packinghouses. The total handling costs of unloading one van were $16.73.

Total system costs.--The total system costs for System 1(forklift truck nonunitized) are presented in table 2.

System 2--Conveyor Nonunitized

Loading.--Although many packinghouses in Florida are replacing this internal handling method with the forklift truck or one of the unitized systems, many continue to load by conveyors. In this method, conveyor belts carry the boxes from the storage area to the loading dock. Portable roller conveyors are placed in the van to carry the boxes from the moving conveyor belts to two stackers in the van. A third worker is used to "feed" the boxes from the moving conveyor belt onto the portable roller conveyor. A fourth worker tallies the boxes and supervises the loading. The labor requirements and costs to load one van with 864 boxes by this method were as follows:

Labor element	Man-hours 1/	Dollars
Remove boxes from conveyor, move down roller conveyor, and stack in vehicle 2/	3.065	7.91
Wait for boxes 2/	.225	.58
Supervise loading 3/	1.097	3.41
Total	4.387	11.90

1/ Adjusted to an 864-box truckload.

2/ Average wage is $2.58 per hour for a loader, Area Wage Survey, Bureau of Labor Statistics--Laborers-Materials Handling, central Florida. Wage rate does not include cost of fringe benefits.

3/ Average wage rate is $3.11 per hour for supervisor, Area Wage Survey, Bureau of Labor Statistics--Laborers-Materials Handling, central Florida. Wage rate does not include cost of fringe benefits.

Equipment inputs per hour per truckload averaged 1.082 equipment-hours, so that with an ownership and operating cost of $3.14 per hour for the mechanized conveyor and portable roller conveyors (table 1), the equipment costs were $3.40. In system 2 the total labor and equipment handling costs of loading one 40-foot highway trailer was $15.30.

Transportation.--At a rate of $0.90 per box to move grapefruit from central Florida to Cincinnati, Ohio, the transportation cost to move an 864-box truckload was $777.60.

Unloading.--The same nonunitized unloading method was used in System 2 as in the System 1. The unloading costs and inputs are the same. Labor inputs were 3.832 man-hours and cost $15.14 per truckload. Equipment inputs per hour were 0.924 equipment-hour for the forklift truck, 0.716 equipment-hour for the palletjack, 2.342 equipment-hours for the pallets and dockplate, and equipment cost $1.59 per truckload. The total labor and equipment handling costs of unloading one van were $16.73.

Total system costs.--The total system costs for system 2 (conveyor nonunitized) are presented in table 3.

System 3--Slipsheet Unitized

Loading.--In this method of unitized handling, a forklift truck was modified with a special push-pull attachment that grasped the slipsheet's lip, which extended beyond the handling unit on one side and pulled the unit onto the tines of the forklift truck. This attachment also included a side-shifting feature that enabled the driver to position the unit without moving the forklift truck.

TABLE 2.--Total system inputs and costs for System 1 (forklift truck nonunitized) to move one 864-box truckload of grapefruit from central Florida to Cincinnati, Ohio

Operation	Labor		Equipment inputs 1/				Equipment costs per truckload	Total handling cost
	Input	Cost	Forklift truck	Palletjack	Pallets	Dockplate		
	Man-hours	Dollars	Equip/hr	Equip/hr	Equip/hr	Equip/hr	Dollars	Dollars
Loading	2.958	8.22	0.659	--	0.920	0.920	1.31	9.33
Transporting	--	--	--	--	--	--	--	777.60
Unloading	3.832	15.14	0.924	0.716	2.342	2.342	1.59	16.73
Total	6.790	23.36	1.583	0.716	3.262	3.262	2.90	803.86

1/ Hourly equipment costs are shown in table 1.

TABLE 3.--Total shipping system inputs and costs for System 2 (conveyor nonunitized) to move one 864-box truckload of grapefruit from central Florida to Cincinnati, Ohio

Operation	Labor		Equipment inputs 1/						Equipment costs per truckload	Total handling cost
	Input	Cost	Mechanical conveyor	Portable conveyor	Forklift truck	Pallet jack	Pallets	Dockplate		
	Man-hours	Dollars	Equip/hr	Equip/hr	Equip/hr	Equip/hr	Equip/hr	Equip/hr	Dollars	Dollars
Loading	4.387	11.90	1.082	1.082	--	--	--	--	3.40	15.30
Transporting	--	--	--	--	--	--	--	--	--	777.60
Unloading	3.832	15.14	--	--	0.924	0.716	2.342	2.342	1.59	16.73
Total	8.219	27.04	1.082	1.082	.924	.716	2.342	2.342	4.99	809.63

1/ Hourly equipment costs shown in table 1.

The only labor required for slipsheet unitized loading, other than the forklift truck operator, was a checker-supervisor who tallied the boxes and supervised the loading. The labor requirements and costs to load one van with 18 slipsheet units of 48 boxes by this method were as follows:

Labor elements	Man-hours	Dollars
Pick up, move, position, and place slipsheet unit in vehicle 1/	0.662	2.06
Delays in going to pick up units 1/	.105	.33
Supervise loading 1/	.234	.73
Total	1.001	3.12

1/ Average wage rate is $3.11 per hour for forklift truck operator and supervisor, Area Wage Survey, Bureau of Labor Statistics--Laborers-Materials Handling, central Florida. Wage rate does not include cost of fringe benefits.

The modified forklift truck was used to load one trailer at a time. The dock foreman supervised the loading operations as a part of his job. The equipment inputs per hour per truckload averaged 0.754 equipment-hour. At an ownership and operating cost of $2.67 per equipment-hour for the modified forklift truck and the dockplate (table 1), the equipment costs were $2.01. The total labor and equipment handling costs of loading one van with 18 units, each with 48 boxes were $5.13

The corrugated, fiberboard (B-flute, 200 lb. test) slipsheet used for this type of unitized handling costs $0.25. These sheets are not treated for moisture resistance. Approximately 16 feet of reinforced nylon tape were required to secure the top layer of each of the 18 units. This means that one 300-foot roll of reinforced nylon 3/4-inch-wide tape was used for each truckload. The tape costs $1.48 per roll. The total cost of unitized materials for one truckload was $5.98.

Transporting.--At a rate of $0.90 per box to move grapefruit from central Florida to Cincinnati, Ohio, the transportation cost to move an 864-box truckload was $777.60.

Unloading.--In this method of unitized unloading, a forklift truck equipped to handle slipsheet unit was used exactly like the one used in the loading method. This modified forklift truck moved the handling unit out of the vehicle and onto the dock where a man placed and positioned it on a pallet. A conventional forklift truck then picked up this pallet and moved it into storage while the modified forklift truck was taken back into the van to remove the next slipsheet unit. Another man (A) was used to place and position the pallets on the dock to help the forklift truck operator. A dock foreman supervised the unloading operation. The labor requirements and costs to unload one van with 18 slipsheet units of 48 boxes were as follows:

Labor elements	Man-hours	Dollars
Manually place and position pallets on the dock 1/	0.340	1.30

Wait for the next slipsheet unit 1/	.124	.47
Pick up, move from vehicle, and place slip sheet units on pallet on dock 2/	.760	3.15
Delays in picking up unit 2/	.198	.82
Pick up palletized unit and move to storage 2/	.503	2.08
Delays in picking up palletized units 2/	.088	.36
Supervise unloading 2/	.240	.99
Total	2.253	9.17

1/ Average wage rate is $3.83 per hour for laborer, Area Wage Survey, Bureau of Labor Statistics--Laborers-Materials Handling, Cincinnati, Ohio. Wage rate does not include cost of fringe benefits.

2/ Average wage rate is $4.14 per hour for forklift truck operator and supervisor, Area Wage Survey, Bureau of Labor Statistics--Laborers-Materials Handling, Cincinnati, Ohio. Wage rate does not include cost of fringe benefits.

One forklift truck with the push-pull attachment was used for each trailer being unloaded. A conventional forklift truck was used to move boxes of citrus from more than one van. A dock foreman supervised the unloading operation. Equipment inputs per hour per truckload averaged 0.610 equipment-hour for the conventional forklift truck, 1.010 equipment-hours for the modified forklift truck, and 1.075 equipment-hours for the pallets and dockplate. At an ownership and operating cost of $1.00 per hour for the conventional forklift truck, $1.47 per hour for the modified forklift truck, and $0.09 per hour for the pallets and dockplate (table 1), the equipment costs were $2.19. The total labor and equipment handling costs of unloading one van were $11.36.

Total system costs.--The total system costs for system 3 (slipsheet unitized) are presented in table 4.

System 4--Palletized

Loading.--In this method of unitized handling, the boxes of citrus are stacked on expendable wooden pallets and are loaded into the van by a conventional forklift truck. The only labor required for palletized loading, other than the forklift truck operator, was a checker-supervisor who tallied the boxes and supervised the loading. The labor requirements and costs to load one van with 18 palletized units each containing 48 boxes of citrus were as follows:

Labor elements	Man-hours	Dollars
Pick up, move, position, and place palletized units in van 1/	0.816	2.54
Delays in picking up units 1/	.048	.15
Supervise loading 1/	.217	.67
Total	1.081	3.36

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[1] Average wage is $3.11 per hour for forklift truck operator and for supervisor, Area Wage Survey, Bureau of Labor Statistics--Laborers-Materials Handling, central Florida. Wage rate does not include cost of fringe benefits.

The forklift truck was used to load one van at a time. The dock foreman supervised the loading operation as a part of his job. The equipment inputs per hour per truckload averaged 0.864 per equipment-hour. At an ownership and operating cost of $1.85 per equipment-hour for the forklift truck and dockplate (table 1), the equipment costs were $1.60. The total labor and equipment handling costs of loading one van with 18 palletized units were $4.96.

The expendable 48- by 40-inch wooden pallets used in this system cost $1.50 each. The same type and amount of reinforced nylon tape were used to secure the top layer of each palletized unit as used in system 3 (slipsheet unitized). The total cost of the expendable pallets and tape for 18 units was $25.48.

Transportation.--At a rate of $0.90 per box to move grapefruit from central Florida to Cincinnati, Ohio, the transportation cost to move an 864-box truckload was $777.60.

Unloading.--In this method of unitized unloading, a forklift truck removed the palletized units from the van and moved them to a storage area. A dock foreman supervised the unloading operation. The labor requirements and costs to unload one van with 18 palletized bins each containing 48 boxes were as follows:

Labor elements	Man-hours	Dollars
Pick up, move from van, and place palletized units in storage 1/	1.263	5.23
Delays in picking up units 1/	.286	1.18
Supervise unloading 1/	.240	.99
Total	1.789	7.40

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[1] Average wage rate is $4.14 per hour for forklift truck operators and for supervisor, Area Wage Survey, Bureau of Labor Statistics--Laborers-Materials Handling, Cincinnati, Ohio. Wage rate does not include cost of fringe benefits.

The forklift truck was used to unload one trailer at a time. The dock foreman supervised the unloading operation as part of his job. The equipment inputs per hour per truckload averaged 1.549 equipment-hours. At an ownership and operating cost of $1.07 per equipment-hour for the forktruck and dockplate (table 1), the equipment costs were $1.66. The total labor and equipment handling costs of unloading one van with 18 palletized units each containing 48 boxes were $9.06.

Total system costs.--The total system costs for system 4 (palletized) are presented in table 5.

TABLE 4.--Total shipping system inputs and costs for System 3 (slipsheet unitized) to move one 864-box truckload of grapefruit from central Florida to Cincinnati, Ohio

Operation	Labor		Modified forklift truck	Equipment inputs 1/			Equipment costs per truckload	Materials	Total handling cost
	Input	Cost		Dockplate	Forklift truck	Pallets			
	Man-hours	Dollars	Equipment-hours	Equip/hr	Equip/hr	Equip/hr	Dollars	Dollars	Dollars
Loading	1.001	3.12	0.754	0.754	--	--	2.01	5.98	11.11
Transporting	--	--	--	--	--	--	--	--	777.60
Unloading	2.253	9.17	1.010	1.075	0.610	1.075	2.19	--	11.36
Total	3.254	12.29	1.764	1.829	.610	1.075	4.20	5.98	800.07

1/ Hourly equipment costs are shown in table 1.

TABLE 5.--Total system inputs and costs for System 4 (palletized) to move one 864-box truckload of grapefruit from central Florida to Cincinnati, Ohio

Operation	Labor		Equipment inputs 1/		Equipment costs per truckload	Materials	Total handling cost
	Inputs	Costs	Forklift truck	Dockplate			
	Man-hours	Dollars	Equipment-hours	Equipment-hours	Dollars	Dollars	Dollars
Loading	1.081	3.36	0.864	0.864	1.60	25.48	30.44
Transporting	--	--	--	--	--	--	777.60
Unloading	1.789	7.40	1.549	1.549	1.66	--	9.06
Total	2.870	10.76	2.413	2.413	3.26	25.48	817.10

1/ Hourly equipment costs are shown in table 1.

System 5--Pallet-pool

This system was synthesized from the data gathered on System 4 (palletized). The only differences between the two systems are the hypothetical pallet-pool arrangement used in system 5 in place of the expendable pallets used in System 4.

The representative pallet was 48- by 40- by 5-inch, 4-way entry, with an average weight of 80 pounds. Pallet expenses were assumed to consist of a purchase price ($4.00 per pallet) and repairs and expenses ($6.00 per pallet for 36 uses) for a total pallet cost of $10.00 per pallet used in a pallet-pool arrangement. The resulting per-use cost is $0.28 per pallet. The total cost per use of the pallets and tape for 18 units was $6.52.

Total system costs.--The total system costs for system 5 (pallet-pool) are presented in table 6.

System 6--Pallet Bins

Loading.--In this method of unitized loading, a forklift truck carried full bulk fiberboard bins on wooden pallets from the storage area into the van. The only labor required for loading, other than the forklift truck operator, was a supervisor who tallied the bins and supervised the loading. The labor requirements and costs to load a van with 36 pallet bins on pallets were as follows:

Labor elements	Man-hours 1/	Dollars
Pick up, move, position, and place pallet bins in van 2/	0.594	1.85
Delays in picking up units 2/	.079	.25
Supervise loading 2/	.149	.46
Total	.822	2.56

1/ Based on 36 pallet bins and pallets with a total payload weight of approximately 39,600 pounds.

2/ Average wage rate is $3.11 per hour for forklift operators and for supervisors, Area Wage Survey, Bureau of Labor Statistics--Laborers-Materials Handling, central Florida. Wage rate does not include cost of fringe benefits.

The forklift truck was used to load one trailer at a time. The dock foreman supervised the loading operation as a part of his job, so that he did not supervise the entire loading but was present periodically. The equipment inputs per hour per truckload averaged 0.713 each for the forklift truck and dockplate. At an ownership and operating cost of $1.85 per equipment-hour (table 1), the equipment costs were $1.32. The total labor and equipment handling costs of loading one van with 36 pallet bins were $3.88.

The fiberboard pallet bins and wooden pallets have a cost per trip per pallet bin and all of its related materials of $2.96. The total cost per trip for the necessary materials was $106.56.

Transportation.--It was assumed that the trucker would not haul the citrus in pallet bins for a lower total charge than boxed citrus, so a $777.60 charge for the fruit plus a $0.90 per pallet charge were levied for a transportation cost to move a 36-bin truckload of $810.00.

Unloading.--In this method of unitized unloading, a forklift truck carried the pallet bins from the van to the storage area. The only labor required was a forklift truck operator and a dock foreman. The labor requirements and costs to unload one van with 36 pallet bins on pallets were as follows:

Labor elements	Man-hours 1/	Dollars
Move units out of vehicle and into storage 2/	0.752	3.11
Delays in going to pick up the units 2/	.271	1.12
Supervise unloading 2/	.188	.78
Total	1.211	5.01

1/ Based on 36 pallet bins and pallets with a total payload weight of approximately 39,600 pounds.

2/ Average wage rate is $4.14 per hour for forklift truck operators and supervisors, Area Wage Survey, Bureau of Labor Statistics--Laborers-Materials Handling, Cincinnati, Ohio. Wage rate does not include cost of fringe benefits.

The bins had a 3-trip usable life and were reused for citrus shipments. This per trip cost is composed of $1.94 for each bin and includes initial cost plus freight in and return freight, $0.60 for each bin cover and includes initial cost plus freight in and return freight, $0.23 for each pallet which has a much longer reuse life and $0.19 for reinforced tape to seal flaps on the bins. The total cost per trip was $2.96.

The forklift truck was used to unload one van at a time. The dock foreman supervised the unloading operation as part of his job. The equipment inputs per hour per truckload averaged 0.950. At an ownership and operating cost of $1.07 per equipment-hour for the forktruck and dockplate (table 1), the equipment costs were $1.02. The total labor and equipment handling costs of unloading one van with 36 pallet bins on pallets were $6.03.

Total system costs.--The total system costs for system 6 (pallet bin) are presented in table 7.

COMPARISON OF TOTAL SYSTEM COSTS

A comparison of the total costs incurred for the six shipping systems is presented in table 8. These total costs ranged from $798.14 to $926.47 per truckload to load at packinghouse, transport, and unload at receiver's warehouse.

TABLE 6.--Total system inputs and costs for System 5 (pallet-pool) to move one 864-box truckload of grapefruit from central Florida to Cincinnati, Ohio

Operation	Labor		Equipment inputs 1/		Equipment costs per truckload	Materials	Total handling cost
	Inputs	Costs	Forklift truck	Dockplate			
	Man-hours	Dollars	Equipment-hours	Equipment-hours	Dollars	Dollars	Dollars
Loading	1.081	3.36	0.864	0.864	1.60	6.52	11.48
Transporting	--	--	--	--	--	--	777.60
Unloading	1.789	7.40	1.549	1.549	1.66	--	9.06
Total	2.870	10.76	2.413	2.413	3.26	6.52	798.14

1/ Hourly equipment costs are shown in table 1.

TABLE 7.--Total system inputs and costs for System 6 (pallet bin) to move one 36 pallet bin truckload of grapefruit from central Florida to Cincinnati, Ohio

Operation	Labor		Equipment inputs 1/		Equipment costs per truckload	Materials	Total handling cost
	Inputs	Costs	Forklift truck	Dockplate			
	Man-hours	Dollars	Equipment-hours	Equipment-hours	Dollars	Dollars	Dollars
Loading	0.822	2.56	0.713	0.713	1.32	106.56	110.44
Transporting	--	--	--	--	--	--	810.00
Unloading	1.211	5.01	.950	.950	1.02	--	6.03
Total	2.033	7.57	1.663	1.663	2.34	106.56	926.47

1/ Hourly equipment costs are shown in table 1.

TABLE 8.--Total system costs for 5 operational and 1 synthesized shipping systems to move one truckload of grapefruit from central Florida to Cincinnati, Ohio

System	Loading			Transportation	Unloading		Total system cost
	Labor	Equipment	Materials		Labor	Equipment	
	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
1, Forklift truck nonunitized	8.22	1.31	--	777.60	15.14	1.59	803.86
2, Conveyor nonunitized	11.90	3.40	--	777.60	15.14	1.59	809.63
3, Slipsheet unitized	3.12	2.01	5.98	777.60	9.17	2.19	800.07
4, Palletized	3.36	1.60	25.48	777.60	7.40	1.66	817.10
5, Pallet-pool	3.36	1.60	6.52	777.60	7.40	1.66	798.14
6, Pallet bin	2.56	1.32	106.56	810.00	5.01	1.02	926.47

The forklift truck nonunitized, conveyor nonunitized, slipsheet unitized, and palletized shipping systems had total operational system costs which fell within a range of $17.03 between most and least expensive. The synthesized pallet-pool system had the lowest total system cost which was $1.93 lower than the least cost operational system, system 3 (slipsheet unitized).

In a comparison of controllable costs (includes labor, equipment, and materials), or those that either shipper or receiver can alter through operations, system 5 (pallet-pool) is the lowest cost at $20.54 per truckload. Of the operational systems, system 3 (slipsheet unitized) was lowest at $22.47. With the exception of System 6 (pallet bin), the other systems fell into the previously mentioned $17.03 range. This difference amounts to 83 percent of controllable costs using the lower cost operational system as a base. This points out the possible significance of the difference between these controllable costs. This is a difference of about 2.1 percent of the least cost operational system. With the small margins within the food industry, this seemingly small percentage difference might be significant. The pallet bin system, despite lower labor and equipment costs for loading and unloading, had such high materials costs that the total system cost was $126.40 or 15.8 percent higher than the least cost operational system.

CONCLUSIONS

The following conclusions are drawn from this research:

- The unitized shipping systems (slipsheet, palletized, and pallet bin) can reduce the labor costs and requirements for loading and unloading.
- The size of the loading and unloading crews required can be reduced by using the unitized shipping systems.
- The total man-hours and equipment-hours required to load and unload a truckload can be reduced by using the unitized shipping systems.
- Higher materials costs per trip greatly offset the savings in labor and equipment costs realized by the pallet bin shipping system.

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